D.7 Geology, Soils, and Paleontology

This chapter provides a summary of existing geological, soil, and paleontological conditions present along the pipeline alignment of SFPP's proposed Concord to Sacramento Pipeline Project, including those associated geologic and seismic hazards. This summary includes a discussion of the potential impacts and mitigation measures for the Proposed Project and its alternatives.

D.7.1 Environmental Baseline

Baseline geologic information was collected from published and unpublished geologic, seismic, and geotechnical literature covering the Proposed Project and the surrounding area. The literature review was supplemented by a limited field reconnaissance of the proposed and alternative alignments. The literature review and field reconnaissance focused on the identification of specific geologic hazards and paleontologic resources.

D.7.1.1 Regional Overview

This section consists of a discussion of the regional topography, geology, seismicity, soils, mineral, and paleontological resources in the project area, followed in Section D.7.1.2 by a more specific discussion of each of these issues along the proposed alignment for each segment of the Proposed Project.

The project alignment traverses both the Coast Ranges Geomorphic Province and the Great Valley Geomorphic Province. The Coast Ranges are characterized by a series of north-northwest trending ranges and valleys, few of which are continuous for more than 100 miles. The province extends from Point Arguello northward to the Klamath Range (Norris and Webb, 1990) and varies in width from a few miles to 70 miles. In the Project Area the Coast Ranges are approximately 40 miles wide.

The Great Valley comprises an approximately 400-mile long by 50-mile wide valley between the Coast Ranges and the foothills of the Sierra Nevada range. The Great Valley ranges in elevation from a few feet to a few hundred feet above sea level. The Valley typically rises very gradually eastward toward the gently sloping foothills of the Sierra Nevada. In contrast, the rise to the Coast Ranges on the western side of the valley is more abrupt. The Sacramento River flows through the northern half of the Valley and empties into San Francisco Bay through the Carquinez Strait, a water gap in the Coast Ranges, cut by the ancestral Sacramento River. East of the Carquinez Strait, the Sacramento–San Joaquin River Delta (Delta) occupies the western margin of the Great Valley.

Topography

The proposed pipeline route traverses diverse topography ranging from the nearly flat floodplains and marshlands along the Delta to the gentle to moderate slopes along the margins of the Coast Ranges. Elevations along the proposed alignment range from sea level at the Carquinez Strait crossing to approximately 100 feet above mean sea level (msl) where the alignment skirts the southeast margin of the Coast Range foothills, along the Carquinez Strait and north to Cordelia.

Geology

The study area for this environmental analysis of the geologic and soil conditions along the Proposed Pipeline route extends 200 feet on either side of the project alignment.

Geologic conditions anticipated during construction of the Proposed Project are summarized in Table D.7-1. This table lists each geologic formation, a description of the formation's general rock type or lithology, the slope stability, excavation characteristics, and age of each formation along the Proposed route.

Table D.7-1. General Geologic Formation Characteristics

Formation Name	Lithology	Slope Stability	Excavation Characteristics	Age
Artificial Fill	Variable, boulders to clay	Variable depending on compaction	Easy	Modern
Bay Mud	Soft saturated silt and clay	Bottom heave in excavations	Easy	Holocene
Alluvium	Boulder, gravel, sand, silt, clay	Slumps on cut slopes, unstable excavations	Easy, boulders may affect trenching	Quaternary
Terrace Deposits	Gravel, sand, silt, and clay	Slumps on cut slopes	Easy	Quaternary
Tehama Formation	Tuffaceous sandstone	Generally stable	Moderate, boulders may affect trenching	Pliocene
Sonoma Volcanics	Tuffs and lava flows	Unstable slopes adjacent to Green Valley Fault	Locally may require heavy ripping or blasting	Pliocene
Domengine Sandstone	Marine sandstone	Unstable slopes adjacent to Green Valley Fault	Locally may require heavy ripping or blasting	Eocene
Unnamed Paleocene Formation	Marine sandstone and shale	Generally stable	Easy to moderate, may require heavy ripping	Paleocene
Panoche Formation	Marine sandstone and shale	Generally stable	Locally may require heavy ripping or blasting	Cretaceous

Sources: Dibblee, 1981; Sims, et al., 1973; Wagner and Bortugno, 1983; Wagner, Bortugno and McJunkin, 1999.

The geologic units exposed at the surface along the proposed route consist primarily of alluvium of poorly consolidated sand, silt, gravel and clay, poorly to moderately consolidated stream and river terrace deposits, estuarine deposits of bay mud, and sandstone and shale of Cretaceous and Tertiary age.

Slope Stability. Large landslides occur along the slopes of the foothills above the alignment along Interstate 680 (I-680) near the Green Valley Fault. Locally the pipeline alignment encroaches on the toe of these mapped landslides where the alignment lies on the west side of I-680. Shallow-seated slumps may occur in moderate to steep natural slopes or man-made cut slopes anywhere along the alignment, especially in deeply weathered Tertiary units. Locally, these slumps may be up to five to six feet deep depending on soil depth, and on the consolidation of the underlying geologic deposits.

Subsidence. Subsidence is generally attributable to four major causes: tectonic activity, groundwater extraction, hydrocompaction, and oil and gas withdrawal. Portions of the Sacramento-San Joaquin River Delta are currently subsiding due to oxidation of subsurface peat layers, but these areas are mainly south and east of the Sacramento River. There is no subsidence mapped along the proposed alignment or the alternatives (Bailey and Harden, 1975; USGS, 2000).

Mineral Resources. Mineral resources identified in the project area are limited to sand and gravel for construction, and several producing natural gas fields in the Delta and Sacramento Valley area.

Soils

Soils along the proposed alignment are mapped as belonging to a wide variety of types along the 70.7-mile length of the project, crossing 18 different and related soil associations comprised of 26 different soil series. The Proposed Project alignment has been selected to predominantly follow established roadways, railways, levees and established transportation and transmission corridors or rights-of-way (ROWs). This alignment limits types of soils expected to underlie the Proposed Project alignment to those found beneath relatively undisturbed areas along stream crossings and agricultural fields, and areas with disturbed soils or artificial fill. Therefore the following discussion will concentrate on the effect of the Proposed Project on areas of relatively undisturbed soils with a brief description of expected conditions within disturbed surface deposits or filled areas.

Surface deposits underlying the proposed alignment consist predominantly of well-drained to somewhat poorly-drained alluvial deposits. These surface deposits are Artificial Fill, Holocene-age Young Alluvium, Pleistocene-age Older Alluvium, Young Bay Mud, Stream Channel Deposits, Landslide Deposits and relatively thin residual soils of various types developed on underlying bedrock formations. The thickness of soil material ranges widely from a few inches for some remnant bedrock soils to over 200 feet of Bay Mud and alluvial deposits in the Central Valley near West Sacramento. Soil thickness is dependent on slope inclination and type of underlying deposits.

Artificial Fill. Localized areas of artificial fill may be encountered beneath roadways, parking lots, artificial levees and railroad embankments along the proposed alignment. Fill is expected to consist of road grade gravel and sand with minor amounts of silt and clay, most likely derived from local surficial deposits and range in thickness from about one to ten feet.

Young Quaternary Alluvium. Holocene (Recent) age young alluvium is found along the proposed alignment as abandoned stream channel deposits, alluvial fan, floodplain and levee deposits. Stream sediments typically consist of sand, gravelly sand, silty sand and sandy clay. Alluvial fans typically consist of silty sand to sandy clay with local gravel lenses. Floodplain deposits are characterized by sandy to silty clay. Natural levee deposits typically consist of medium to fine-grained sand, silt and clay.

Older Quaternary Alluvium. The Pleistocene-age older alluvial deposits along the proposed alignment are a combination of older alluvial fan, floodplain and river channel deposits exhibiting a moderately higher degree of consolidation than those of Holocene age. These deposits typically consist of sand, gravel, silt and clay in varying amounts depending on their different depositional origins.

Young Bay Mud. Young Bay Mud deposits are found along the proposed alignment on the low areas along the Carquinez Strait and along the Sacramento River Delta near Fairfield and Suisun City. These deposits typically thin toward their margins and may interfinger with or underlie adjacent surface alluvium. Bay Mud deposits typically consist of soft saturated silt and clay with local lenses of sand, ranging in thickness from a few feet to over 200 feet along the Carquinez Strait. These sediments are typically very high in chloride and sulfide compounds which exhibit moderate to high corrosivity to concrete and uncoated metals.

Stream Channel Deposits. The stream channel deposits along the proposed alignment are expected to consist of varying amounts of loose to medium dense gravel, sand, silt and clay with minor cobbles or boulders in streams draining the hills of the Coast Ranges along I-680. These deposits are of limited extent along the project alignment near the surface, but may be more extensive in the subsurface near stream crossings where they may be of concern with respect to liquefaction.

Landslide Deposits. Landslide deposits are present beneath the Proposed Project alignment along the hills of the Coast Ranges along I-680, predominantly near the traces of the Green Valley Fault. These deposits typically consist of poorly consolidated chaotic mixtures or accumulations of clay, silt, sand and gravel, and may include boulders of bedrock materials exhibiting various degrees of weathering.

Faults and Seismicity

The seismicity of the project area is dominated by the northwest trending San Andreas fault system. The San Andreas fault system is responding to stress produced by the relative motions of the Pacific and North American Tectonic Plates. This stress is relieved by strain, predominantly as right lateral strike slip faulting on the San Andreas, Hayward, Calaveras, and related faults. The effects of this strain also include mountain building, basin development, deformation of Quaternary deposits, widespread regional uplift, and the generation of earthquakes.

The Coast Ranges are characterized by numerous geologically young faults. These faults can be classified as historically active, active, potentially active, or inactive, based on the following criteria (Hart, 1994):

- Faults that have generated earthquakes accompanied by surface rupture during historic time (approximately the last 200 years), and faults that exhibit a seismic fault creep are defined as Historically Active.
- Faults that show geologic evidence of movement within Holocene time (approximately the last 11,000 years) are defined as Active.
- Faults that show geologic evidence of movement during the Quaternary (approximately the last 2,000,000 years) are defined as Potentially Active.
- Faults that show direct geologic evidence of inactivity during all of Holocene time or longer may be classified as Inactive.

Although it is difficult to quantify the probability that an earthquake will occur on a specific fault, this classification is based on the assumption that if a fault has moved during the Holocene epoch, it is likely to produce earthquakes in the future. Historically, the San Francisco Bay Area has been one of the more seismically active regions of the world, with local faults having produced numerous small magnitude and moderate to large magnitude earthquakes ($M_w \geq 6$)[1]. The Working Group on Northern California Earthquake Probabilities has estimated that there is a cumulative 70 percent chance of one or more large ($M_w \geq 7$) earthquakes occurring within the San Francisco Bay region between 2000 and 2030 (WGNCEP, 1999).

Since periodic earthquakes accompanied by surface displacement can be expected to continue in the study area through the lifetime of the Proposed Project, the effects of strong ground shaking and fault rupture are of primary concern to safe operation of the proposed pipeline and associated facilities.

[1] M_w or moment magnitude is the currently accepted scale for measuring earthquake magnitude and is based on the energy released during a seismic event (earthquake). The moment magnitude scale is comparable to the Richter scale for magnitudes up to 6.0. Above magnitude 6.0 the Richter magnitude underestimates the energy released.

Strong Ground Shaking

The intensity of earthquake induced ground motions can be described using peak site accelerations, represented as a fraction of the acceleration of gravity (g). The California Geological Survey's Probabilistic Seismic Hazard Assessment Maps for the Santa Rosa, San Francisco, and Sacramento quadrangles (Petersen, et al., 1996) were used to predict peak ground accelerations along the Proposed Pipeline alignment. The Probabilistic Seismic Hazard Assessment Maps depict peak ground accelerations with a 10 percent probability of exceedance in 50 years. The results are presented in Table D.7-2. Strong ground shaking should be expected to affect the pipeline as a result of earthquakes occurring on any fault in the vicinity of the project area, not only those faults listed in Table D.7.3.

Table D.7-2. Peak Ground Acceleration

Proposed Pipeline Milepost	Peak Ground Acceleration
0.0 to 24.5	Greater than 0.7g
24.5 to 34.0	0.4 to 0.7g
34.0 to 44.5	0.3 to 0.4g
44.5 to 54.0	0.2 to 0.3g
54.0 to 70.0	0.1 to 0.2g

Table D.7-3. Active and Potentially Active Fault Crossings

Fault Name	Milepost	Activity	Maximum Capable Magnitude	Offset	Potential Fault Displacement*
Concord	0.2 to 0.4	Active	6.9	Right Lateral	3-6 feet
Green Valley	10.1 to 10.7	Active	6.9	Right Lateral	3-6 feet
Cordelia	18 to 18.3	Active	6.5	Right Lateral	1-2 feet
Vaca	31.3	Potentially Active	Unknown	Right Lateral	Unknown

Source: USGS 1996

Fault Rupture

Perhaps the most important single factor to be considered in the seismic design of pipelines crossing active faults is the amount and type of potential ground surface displacement. There are three active faults (and one potentially active fault) crossed by the project alignment, but these faults have not generated historic surface rupture. Therefore, assessment of anticipated displacement is dependent on statistical correlations between earthquake magnitude and displacement. Strike-slip earthquakes of magnitude 6.0 or greater are likely to produce surface fault rupture and offset.

Active or potentially active faults crossing the proposed route are summarized in Table D.7-3. Data presented in this table include estimated earthquake magnitudes and fault surface displacements. The locations of these fault crossings are described in more detail in the discussion of each segment, below.

Regionally damaging earthquakes could also occur on other known faults in the central California area. It is also very important to note that earthquake activity from unmapped subsurface faults is a distinct possibility that is currently not predictable. For example, the Great Valley fault system at the Coast Ranges–Sierra Block boundary are discontinuous segmented blind thrust faults that have no apparent surface exposure but are interpreted as exhibiting historic activity (Wakabayashi and Smith, 1994).

Liquefaction

Liquefaction is the phenomenon in which saturated granular sediments temporarily lose their shear strength during periods of strong, earthquake induced, ground shaking. The susceptibility of a site to liquefaction is a function of the depth, density, and water content of the granular sediments and the magnitude and frequency of earthquakes in the surrounding region. Saturated, unconsolidated silts, sands, and silty sands within 50 feet of the ground surface are most susceptible to liquefaction. Liquefaction related phenomena include lateral spreading, ground oscillation, flow failures, loss of bearing strength, subsidence and buoyancy effects (Youd, 1978). In addition, densification of the soil resulting in vertical settlement of the ground can also occur.

In order to determine liquefaction susceptibility of a region, three major factors must be analyzed. These include: (a) the density and textural characteristics of the alluvial sediments; (b) the intensity and duration of ground shaking; and (c) the depth to groundwater. Much of the surface materials beneath the proposed alignment meet the criteria for liquefaction: saturated granular sediments in the marshy areas in the Delta where intense ground shaking is likely to occur. Specifically, these conditions occur in the low-lying alluvial deposits, and creek and river crossings including the Yolo Bypass. Locally, Younger Bay Mud deposits contain granular layers that are also susceptible to liquefaction. Older, finer or coarser grained, indurated, and/or well-drained materials are less susceptible.

Seismically Induced Subsidence/Differential Settlement

Localized subsidence may occur in unconsolidated soils during earthquake shaking as the result of a more efficient rearrangement of individual soil particles. Stream channels and recent valley alluvium are generally most susceptible to earthquake-induced subsidence. Failures of pipelines tend to occur at the interface between a softer unit and a stiffer unit due to the settlement that occurs within the softer unit. The unconsolidated sediments underlying water crossings are typical examples of such conditions. Many water pipeline ruptures occurred in the Marina District of San Francisco as a result of differential settlements resulting from ground shaking during the Loma Prieta earthquake of 1989. Pipeline damage corresponded to areas of greatest surface settlement (USGS, 1992).

Seiches

A seiche is a wave or series of waves generated by seismic shaking or of a displacement of water or land within an enclosed body of water or in a bay. Seiches tend to "slosh" back and forth between affected shorelines, unlike tsunamis, which impact the shoreline with one or more waves coming from one direction. Potential impacts to the pipeline from seiche waves would be limited to the approaches to the Carquinez Strait crossing. While planning for seiches is speculative, the conditions for generating significant waves are ideal, with fault displacement direction of the Concord-Greenville Fault at nearly right angles to the major axis of the waterbody.

Paleontology

Paleontological resources, like archaeological resources, represent a limited, non-renewable, and sensitive scientific and educational resource. In California, negative impacts to such resources are addressed under regulations of the California Environmental Quality Act (CEQA), Appendices G and I.

Determination of the "significance" of a fossil can only occur after a fossil has been found and identified by a qualified paleontologist. Until then, the actual significance is unknown. The most useful designation for paleontological resources in an EIR document is the "sensitivity" of a particular geologic unit. Sensitivity refers to the likelihood of finding significant fossils within a geologic unit. In Northern California, fossils of land-dwelling vertebrates are considered significant. Such fossils are found in fluvial and lake deposits.

The following levels of sensitivity recognize the important relationship between fossils and the geologic formations within which they are preserved.

- **High Sensitivity.** High sensitivity is assigned to geologic formations known to contain paleontological localities with rare, well-preserved, and/or critical fossil materials for stratigraphic or paleoenvironmental interpretation, and fossils providing important information about the paleobiology and evolutionary history (phylogeny) of animal and plant groups. Generally speaking, highly sensitive formations are known to produce vertebrate fossil remains or are considered to have the potential to produce such remains.
- **Moderate Sensitivity.** Moderate sensitivity is assigned to geologic formations known to contain paleontological localities with moderately preserved, common elsewhere, or stratigraphically long-ranging fossil material. The moderate sensitivity category is also applied to geologic formations that are judged to have a strong, but unproven potential for producing important fossil remains (e.g., Pre-Holocene sedimentary rock units representing low to moderate energy, of marine to non-marine depositional settings).
- **Low Sensitivity.** Low sensitivity is assigned to geologic formations that, based on their relative youthful age and/or high-energy depositional history, are judged unlikely to produce important fossil remains. Typically, low sensitivity formations may produce invertebrate fossil remains in low abundance.
- **Marginal Sensitivity.** Marginal sensitivity is assigned to geologic formations that are composed either of pyroclastic volcanic rocks or metasedimentary rocks, but which nevertheless have a limited probability for producing fossil remains from certain sedimentary lithologies at localized outcrops.
- **Zero Sensitivity.** Zero sensitivity is assigned to geologic formations that are entirely plutonic (volcanic rocks formed beneath the earth's surface) in origin and therefore have no potential for producing fossil remains.

There are several geologic units that occur along the proposed alignment that meet the criteria of moderate to high sensitivity. These areas are defined in the following section.

D.7.1.2 Environmental Setting: Proposed Project

For the purposes of this analysis, the project area has been divided into seven segments, which fall into three general geologic areas. The Coast Ranges section extends from Concord to Cordelia (MP 0.0–15.2) and encompasses the first two segments. The Delta section extends from Cordelia through Fairfield (MP 15.2–MP 30.7) and includes Segments 3 and 4. The Great Valley section extending from east of Fairfield to West Sacramento (MP 30.7–MP 69.9) contains Segments 5, 6, and 7 (the Wickland Connection).

Segment 1 (MP 0–6.1) – Contra Costa County and Carquinez Strait

This segment of the proposed alignment lies within the Coast Ranges and traverses the Walnut Creek drainage and the gently sloping foothills on the south side of the Carquinez Strait and includes the Strait crossing.

Topography. Gently sloping hills and valleys of the Coast Ranges and the Carquinez Strait crossing (MP 4.8 to MP 6.1) dominate the topography of the first segment of the Proposed Project alignment. Elevations range from sea level to about 80 feet above sea level at the southern end of the Carquinez Strait crossing, but generally range between sea level and about 30 feet along most of this Segment.

Geology. Geologic conditions along the Coast Ranges Section of the proposed pipeline alignment range from the soft saturated Younger Bay Mud to the Cretaceous Panoche Formation.

The alignment begins on shale bedrock of the Cretaceous Panoche Formation, traverses areas underlain by Younger Bay Mud at the Walnut Creek, Grayson Creek and Pacheco Slough crossings and then crosses an area underlain by a combination of alluvium and bedrock of the Panoche Formation to Valve

No. 2 at approximately MP 3.7. Between MP 3.7 and MP 7.7, which includes the Carquinez Strait crossing, the alignment traverses an area underlain by Younger Bay Mud.

Soils. Soils developed on shale of the Cretaceous Panoche Formation are predominantly of the Altamont and Dibble Series (Welch, 1977). Soils of the Altamont series typically consist of 28 inches of clay with 10 inches of silty clay loam subsoil overlying weathered bedrock. The clay exhibits high expansivity and corrosivity, while the subsoil exhibits moderate expansivity and high corrosivity. The soils of the Dibble series consist of a loam or clay loam to a depth of 13 to 18 inches with a light clay subsoil to 30 to 36 inches overlying weathered bedrock. The surface loam and clay loam exhibit moderate expansivity and corrosivity and the subsoils exhibit high potentials for both.

Faults. The proposed alignment crosses an active surface trace of the Concord Fault at approximately MP 0.1 adjacent to the Concord Station, and at MP 0.3 beneath Walnut Creek and within the horizontal directionally drilled (HDD) stream crossing of Walnut and Grayson Creeks. The alignment lies within the Alquist-Priolo Earthquake Hazard Zone for the Concord Fault between about MP 0.0 and 0.5 and from MP 0.6 to 0.7. A recent URS report estimates the width of the Concord fault zone is likely around 16 feet, but may be as wide as 45 feet or more, and that the estimated strike-slip offset is 3.5 feet based on maximum earthquake magnitude, but could be as much as 7.1 to 9.5 feet ("maximum horizontal displacement", URS, April 2003).

Paleontology. The alignment traverses modern marsh and bay mud deposits in the first mile (low sensitivity), from MP 1.0 to 5.0 the alignment crosses Cretaceous sandstone and shale until reaching the water's edge. Cretaceous units in this part of California are marine deposits and therefore are unlikely to contain significant vertebrate fossils (low sensitivity).

Phase 1 Carquinez Strait Crossing

The proposed Phase 1 crossing of the Carquinez Strait would use the existing 14-inch pipeline that was constructed 36 years ago using cut-and-cover methods to place it beneath the surface of the channel bottom sediments.

Phase 2 Carquinez Strait Crossing

The proposed Phase 2 crossing of the Carquinez Strait within 12 years by means of a single HDD would encounter Young Bay Mud, and potentially Older Bay Mud and river channel deposits of sand and gravel. These different deposits would not pose a difficulty in drilling, but may pose a potential problem with the behavior of the drilled portion of the pipeline under seismic conditions due to differential settlement, liquefaction, and lateral spreading.

Segment 2 (MP 6.1–17.6) – Benicia and I-680 Frontage

North of the Carquinez Strait crossing, Segment 2 skirts the toe of the foothills on the north side of the Strait to approximately MP 15.2. Slopes greater than 20 percent occur along the banks of natural stream channels and gullies and along the natural hillsides.

Topography. The topography along Segment 2 consists of a level portion immediately north of the Strait crossing and extending to about MP 8.7, then follows I-680 along Lopes Road where the alignment varies in elevation from ridge to ridge through numerous roadcuts. The elevation generally ranges from about 30 feet to 100 feet along Lopes Road to MP 15.4 where it crosses beneath I-680.

From MP 15.4 to MP 17.6 the alignment follows along the east side of Ramsey Road over level terrain with elevations ranging from about 10 to 30 feet above mean sea level.

Geology. Segment 2 crosses Young Bay Mud from MP 6.1 at the northern end of the Carquinez Strait crossing to MP 7.5 just south of I-680. From MP 7.5 to MP 10.1 the proposed alignment crosses Young and Older Alluvium, which form a thin veneer over older bedrock of Panoche Formation and Domengine Sandstone where the alignment crosses Lake Herman Road (MP 9.5 to 9.7). Alluvium is also mapped from MP 10.7 to 10.9, MP 11.2 to 11.4, MP 12.1 to 12.9, MP 13.9 to 14.5, MP 14.9 to 15.1, and MP 15.3 to the end of the Segment at MP 17.5. These alluvial deposits are mapped as alluvial fans and terraces above the marshlands to the east (Helley and Graymer, 1997; Dibblee, 1981).

East of the Green Valley Fault, bedrock exposures of Sonoma Volcanics and Tehama Formation underlie the proposed alignment from MP 10.5 to 10.7, MP 10.9 to 11.2, MP 11.4 to 12.1, MP 12.9 to 13.9, MP 14.5 to 14.6, MP 14.9 to 15.1, and MP 15.2 to 15.3. The Sonoma Volcanics primarily consist of tuffs and andesite flows. The Tehama Formation consists of volcaniclastic sandstone with abundant volcanic ash. Both of these bedrock units are highly sheared and deeply weathered in the vicinity of the Green Valley Fault.

Segment 2 overlies mapped areas of recent landslide deposits from MP 10.1 to 10.5, MP 14.6 to 14.9, and MP 15.1 to 15.2 (Bortugno, 1987). The landslide deposits mapped between MP 10.1 and 10.5 are within the Alquist-Priolo Zone[2] (A-P Zone) for the Green Valley Fault and obscure the surface traces of the fault, as mapped by the CGS (1977). URS recently completed an investigation of these landslides (URS, May 2003). URS drilled three borings along the proposed alignment within the mapped slide area, finding deeply weathered Cretaceous shale, weathered Domengine (Lower Tertiary) sandstone, and material so thoroughly sheared and weathered that it is most likely fault gouge of the Green Valley Fault. Just north of the mapped slide area another boring encountered hard rocks of the Sonoma Volcanics. None of the borings appeared to contain landslide debris. It is likely that the mapped landslide is shallow and its slide plane lies above the elevation of the borings, in which case the proposed pipeline would not be impacted.

URS also investigated the mapped landslides north of the Green Valley Fault zone between MP 14.6 and 15.2 (URS, May 2003). Their findings indicate that the mapped landslide at MP 14.6 to 14.9 is shallow and its slide plane lies above the elevation of the borings, in which case the proposed pipeline will not be impacted. At MP 15.1, the URS boring encountered landslide debris to approximately 8 feet below the surface, though a distinct slide plane was not evident and the slide may be thicker. URS's recommendation to keep the pipeline deeper than 14 feet below this slide (the HDD crossing is planned for 18 feet deep) seems sufficient to avoid damage to the pipeline from future movement by the landslide.

Soils. Segment 2 of the proposed alignment overlies areas Quaternary alluvium consisting of Young Bay Mud, artificial fill, alluvial fans and terraces and landslide deposits. The alignment lies within and adjacent to roadways, levees and railways along most of this Segment which consist of a surficial layer of artificial fill. The soils of the alluvial deposits underlying the artificial fill are mapped as predominantly loam or gravelly loam of the Corning and Antioch Series on fans and terraces derived from the Panoche and Domengine Formations west of the Green Valley fault (Bates, 1977). The surficial soils of the Corning and Antioch Series exhibit low expansivity and corrosivity to depths of 14 to 18 inches, and are typically underlain by clay subsoils exhibiting high expansivity and corrosivity.

2 Alquist-Priolo Earthquake Hazard zones are defined in Section C.7.2.2.

The soils of the alluvial deposits underlying the artificial fill east of the Green Valley fault are mapped as loam or clay loam of the Dibble Series on the alluvial fans and landslide deposits derived from the Sonoma Volcanics. The loamy soils are typically 10 to 14 inches deep with a clay loam subsoil extending to between 30 and 36 inches overlying weathered bedrock. Clay loam soils of the Dibble Series lack the surface loam, extending from the surface to 30 to 36 inches and overlie weathered bedrock. Loamy surface soils exhibit moderate expansivity and low corrosivity with clay soils and subsoils exhibiting high expansivity and corrosivity.

Faults. Segment 2 of the Proposed Project alignment crosses two mapped traces of the active Green Valley Fault at approximately MP 10.3 and MP 10.5. The proposed alignment lies within the designated A-P Zone for these two fault traces between MP 10.1 and MP 10.7. North of the fault crossings, the proposed alignment lies subparallel to the Green Valley fault zone remaining within 0.8 mile of the mapped surface traces between MP 9.0 and MP 15.6 at the end of Segment 2 (CGS, 1977, 1993a,b). A recent URS report estimates the width of the fault zone around the two traces of the Green Valley Fault is 25 feet (12.5 ft to either side of each trace) and that the estimated strike-slip offset is 3.5 feet based on maximum earthquake magnitude, but could be as much as 7.1 to 9.5 feet ("maximum horizontal displacement", URS, April 2003).

Paleontology. The alignment crosses Cretaceous sandstone and shale, an area of Tertiary-aged Domengine sandstone, and modern alluvium and terrace deposits. From MP 11.0 to about 15.5, the alignment crosses the Pliocene Tehama Formation. The Tehama has yielded significant fossils in the past and should be considered a moderate to high sensitivity unit. Domengine sandstone as well as the Cretaceous strata are marine units and are unlikely to contain significant vertebrate fossils (low sensitivity).

Segment 3 (MP 17.6–24.5) – Cordelia

Beginning at MP 17.6, Segment 3 of the proposed alignment traverses the northwestern margin of the Sacramento River Delta, crossing agricultural lands, a low bedrock ridge, and several creeks, along the southern margin of the City of Fairfield.

Topography. The topography of this segment is very flat ranging from about five to 30 feet in elevation with the exception of one bedrock ridge east of Cordelia between Cordelia and Suisun Creeks herein referred to as Cordelia Hill. The proposed alignment passes over this ridge through a saddle at approximately 100 feet in elevation.

Geology. Segment 3 primarily overlies alluvial deposits of Quaternary age with minor bedrock exposures consisting of volcanic tuffs and andesite flows of the Sonoma Volcanics outcropping between MP 19.7 and MP 20.1. Pipeline excavation may also encounter shallow bedrock extending east to Thomasson Lane at MP 20.3. There is a small bedrock landslide mapped upslope of the proposed alignment on Cordelia Hill, on the southern side of the alignment (MP 19.8).

The Quaternary deposits underlying the alignment are mapped primarily as alluvium and estuarine deposits of Young Bay Mud (Wagner and Bortugno, 1982) with minor amounts of artificial fill along roads, levees, and railroad embankments. The proposed alignment overlies alluvium from MP 17.6 to 18.9 and MP 20.1 to 23.8, and estuarine deposits from MP 18.9 to 19.7 and MP 23.8 to 24.5. These deposits of alluvial and estuarine origin interfinger and overlap both laterally and vertically, and consist of clay, silt, sand and gravel sized particles in varying proportions. These deposits are generally poorly consolidated, and are considered to be susceptible to liquefaction.

Soils. The proposed alignment within Segment 3 crosses a large expanse of cultivated soil along the transmission line ROW east of I-680. The soils of this area are mapped as mostly Rincon clay loam and Clear Lake clay soils, both exhibiting high expansivity and corrosion potential (Bates, 1977).

Faults. The alignment along Segment 3 crosses the Cordelia Fault across level agricultural fields along the transmission line ROW at MP 18.2. The Cordelia Fault is classified as an active fault with an associated A-P Earthquake Hazard Zone between MP 18.0 and MP 18.2 of the proposed alignment. The Green Valley Fault is located approximately 0.6 mile west of the western end of this segment, extending along the margin of the hills west of I-680. A recent URS study estimates the possible maximum earthquake magnitudes that could be generated by the Cordelia Fault range from 6.0 to 6.5. No estimate of amount of fault offset was given (URS, April 2003).

Paleontology. Most of the alignment crosses modern marsh and alluvium (low sensitivity). Between MP 17.6 and MP 18.3 the alignment crosses an alluvial fan mapped as “Old alluvium” (moderate sensitivity). At MP 20.0 the alignment crosses a hill underlain by volcanic units that are considered low to marginal sensitivity.

Cordelia Mitigation Segment

The Cordelia Mitigation Segment for the proposed pipeline (recommended in Mitigation Measure BB-14a) would occur along Cordelia Road in unincorporated Solano County as a measure to avoid impacts to the sensitive biological area of the Cordelia Marsh and Slough. The 2.6-mile segment diverges from the proposed route at MP 17.6 and rejoins the proposed route at approximately MP 20.0. The Cordelia Mitigation Segment parallels Ramsey Road until Cordelia Road, where it continues along Cordelia Road to the UPRR ROW where it rejoins the proposed route (see Figure D.4-3). Similar to the Proposed Project, the Cordelia Mitigation Segment would cross the Alquist-Priolo zoned Cordelia Fault and would be subject to fault rupture, ground shaking, and potential liquefaction. The mitigation segment would avoid a landslide area mapped from MP 19.8 to 19.9 of the proposed route.

Segment 4 (MP 24.5–30.7) – Fairfield/Suisun City

Beginning at the Highway 12 crossing in the City of Fairfield, the proposed alignment traverses the lowlands surrounding the Sacramento River Delta then encroaches upon the foothills of the Coast Ranges near Travis Air Force Base.

Topography. Segment 4 traverses nearly level terrain predominantly along established roads and railways through Fairfield. The alignment begins near sea level at Suisun Slough and the elevation gradually increases reaching a maximum elevation of about 85 feet along Vanden Road.

Geology. Segment 4 traverses predominantly artificial fill within roadways, parking lots, and along railway embankments. This artificial fill overlies areas mapped as young alluvial fans throughout Fairfield and estuarine deposits of young Bay Mud near Suisun Slough (Wagner and Bortugno, 1982; Wagner, et al., 1981). A small outcrop of undifferentiated Paleocene marine sandstone and shale is mapped between MP 29.9 and MP 30.4 near the intersection of Peabody and Vanden Roads (Sims, et al., 1973).

Soils. The soils found along this segment, beneath the surficial fill underlying roads and railway embankments are only found above the bedrock exposure of Paleocene marine sandstone and shale. This soil is mapped as belonging to the Antioch–San Ysidro complex and consists of about equal areas of loam and sandy loam with zero to two percent, and two to nine percent slopes. These soils are beneath or adjacent to established roadways and exhibit high shrink-swell potential and corrosivity (Bates, 1977).

Faults. There are no known surface faults mapped crossing Segment 4.

Paleontology. The entire alignment crosses modern marsh and alluvium (low sensitivity). However, from MP 26.1 to MP 30.8, units are identified as "Older alluvium" and may contain Pleistocene-aged deposits. These units of "Older alluvium" are considered moderate to high sensitivity.

Segment 5 (MP 30.7–65.1) – Solano and Yolo Counties Agricultural Area

Segment 5 extends from MP 30.7 to the western edge of West Sacramento at MP 65.1 traversing predominantly agricultural lands within or adjacent to existing roads, railways, and transmission line rights-of-way.

Topography. Beginning at MP 30.7, north of Travis Air Force Base, the proposed alignment traverses rural, flat-lying agricultural lands and low-lying bedrock hills between elevation 80 and 140 feet above MSL to MP 33.5. From MP 33.5 on McCrory Road, the alignment descends gently to the east gradually decreasing from an elevation of about 80 feet to between 10 and 25 feet above MSL along the railroad right-of-way and maintains this elevation range for the remainder of the distance to MP 65.1.

Geology. This segment is predominantly underlain by Young Alluvium and Older Alluvium, with minor outcrops of consolidated bedrock near Fairfield in the low-lying hills. The bedrock outcrops are sandstone and shale of Cretaceous to Tertiary age in the region above 80 feet in elevation. Cretaceous bedrock is mapped along Vanden Road between MP 30.9 to 31.3 and MP 31.5 to 31.7, west of Cannon Hill. Cannon Hill is a bedrock outcrop of the Tertiary Markley Formation, an orange-brown-weathering micaceous sandstone, which underlies the alignment between Vanden Road and McCrory Road from MP 32.3 to 32.9.

On the eastern portion of Segment 5, the alignment crosses areas of a dissected pediment consisting of local occurrences of the Tehama Formation, and Older and Younger Alluvium with local artificial fill along roadways, levees and railroad embankments. The Tehama Formation is a moderately indurated gravelly sand with abundant volcanic ash and cobbles which underlies the alignment between MP 35.2 and MP 36.0. The remainder of Segment 5 is underlain by Quaternary-age alluvium and localized fill consisting of unconsolidated silt and clay with lenses of fine sand and occasional gravels.

Soils. The soils along Segment 5 are predominantly developed on older alluvium consisting of Pleistocene-age alluvial fan and stream terrace deposits. Where this segment does not underlie roadways or railroad embankments of artificial fill, it closely parallels these structures and is placed along the margins of agricultural fields. Segment 5 crosses several areas of mapped bedrock outcrops (Sims, et al., 1973; Wagner, et al., 1981) with surficial soils and subsoils exhibiting moderate to high shrink-swell potential and high corrosivity (Andrews, 1972 – Yolo Co., and Bates, 1977 – Solano Co.). These soils are developed on the Domengine Sandstone, Markley Sandstone, and Tehama Formation as described in the Geology Section for Segment 5. These soils generally consist of 14 to 18 inches of loam or sandy loam overlying a clay or clay loam subsoil exhibiting high expansive and corrosive potential. There are no mapped peat deposits along this segment of the alignment; therefore subsidence due to peat oxidation is not expected to be an issue for the project (USGS, 2000).

Faults. Segment 5 crosses the Vaca Fault at approximately MP 32.4, which is mapped along the western margin of Cannon Hill (Sims, et al., 1973). The California Geological Survey (CGS) has classified the Vaca Fault as potentially active based on evidence of activity within the Late Quaternary (Jennings, 1994).

Paleontology. Most of the alignment crosses modern alluvium (low sensitivity). The alignment crosses deeply weathered Lower Tertiary units (marine) at MP 31.0 to 32.0 (low sensitivity). There is one small occurrence of Pliocene Tehama Formation at MP 35.3 to 36.0 (moderate to high sensitivity), and a larger occurrence of "Older alluvium" that may contain Pleistocene-age deposits (moderate to high sensitivity) at MP 37.5 to 40.1.

Segment 6 (MP 65.1–69.9) – West Sacramento

Beginning at the western edge of West Sacramento crossing beneath the Sacramento Bypass Toe Drain, the proposed alignment follows within or alongside established roadways and railways over flat lying terrain all the way to the SFPP West Sacramento Station. This segment runs near and parallel to the Deep Water Ship Channel and Turning Basin.

Topography. Segment 6 extends over nearly flat terrain with an elevation ranging from about sea level to 25 feet.

Geology. The Segment 6 alignment is underlain by Quaternary-age alluvium and localized fill consisting of a wide range of materials. These materials are mostly unconsolidated silt and clay with lenses of fine sand and occasional gravel. Liquefaction potential is the only significant geologic hazard along this section of the alignment. The alluvium mapped along this segment has a shallow water table and is shown to have high liquefaction susceptibility (URS, 2002).

Soils. The entire length of Segment 6 lies within areas of disturbed soil either within or adjacent to existing roadways, railways and levees of artificial fill. These artificial fills typically overlie alluvium of basin fill and stream channel deposits consisting of clay, silty clay, and silt, with local lenses of sand and gravel (Welch, 1977).

Faults. Segment 6 crosses no known surface rupturing faults.

Paleontology. The entire alignment crosses modern marsh and alluvium (low sensitivity).

Segment 7 – Wickland Connection

The Wickland Connection is located within the flat, alluvial-filled Sacramento Valley below an elevation of 30 feet above Mean Sea Level. The alignment extends for 4,100 feet and is underlain by Quaternary-age alluvium and localized artificial fill. The alluvium consists of a wide range of materials, including clay, silt, sand, and gravel. These materials are mostly unconsolidated silt and clay with lenses of fine sand and occasional gravels. Liquefaction potential is the only significant geologic hazard along this section of the alignment. The alluvium mapped along this segment has a shallow water table and is shown to have high liquefaction susceptibility.

Paleontology. The entire alignment crosses modern marsh and alluvium (low sensitivity).

D.7.1.3 Environmental Setting: Existing Pipeline ROW Alternative

The environmental setting of the Existing Pipeline ROW Alternative is similar with respect to the geology, soils and paleontology as that for the proposed alignment discussed above. Fault crossings along this alternative are defined below.

Fault Crossings

The Existing Pipeline ROW Alternative alignment crosses two traces of the active Concord Fault at Existing Milepost (EMP) 2.2, and EMP 2.4, and lies within 250 feet of the surface trace for over a mile. The Existing Pipeline Alignment lies within the A-P Zone for the Concord Fault between EMP 0.0 and EMP 1.0 and again from EMP 2.1 to EMP 2.8.

The Existing Pipeline ROW Alternative alignment crosses three mapped traces of the Green Valley Fault along the UPRR right of way between approximately 0.5 and 1.0 mile north of Lake Herman Road. The Existing Pipeline ROW Alternative lies within the A-P Zone for the Green Valley Fault from about 0.2 to 1.1 miles north of Lake Herman Road measured along the UPRR ROW. This alternative avoids crossing the Cordelia Fault. The Existing Pipeline ROW Alternative crosses the potentially active Vaca Fault at the same location as the Proposed Project, on the western margin of Cannon Hill along Vanden Road. Potential fault zone widths and fault offsets are similar to those described for the Proposed Project above.

Geology, Soils, and Paleontology Along Existing Pipeline ROW Mitigation Segments

Two mitigation segments are suggested for the Existing Pipeline Alternative. Mitigation Segment EP-1 (Mitigation Measure BB-7b) is suggested to reduce biological resources impacts and Mitigation Segment EP-2 (Mitigation Measure LU-1d) is recommended in Section D.9 to reduce land use impacts through downtown Davis. Geologic, soils, and paleontologic resources along these mitigation segments are described below.

Mitigation Segment EP-1

This segment would diverge from the Existing Pipeline ROW Alternative route and follow a portion of the Proposed Project route. It would diverge near Pierce Lane along Goodyear Road. As the Existing Pipeline ROW Alternative would follow the UPRR ROW and bear northeast across the Suisun Marsh and Slough, this segment would continue north paralleling access roads along I-680 until just north of Smith Drive on Ramsey Road. Just north of Smith Drive, the proposed pipeline route would turn northeasterly and follow an existing transmission corridor and a dirt road through the Cordelia Marsh and across the Cordelia Slough. On the east side of the slough, the proposed route would briefly enter the City of Fairfield and would parallel the UPRR right-of-way until MP 22.0 where it would intersect with and turn east adjacent to Cordelia Road. The mitigation segment would return to unincorporated Solano County along Cordelia Road. The Mitigation Segment EP-1 for the Existing Pipeline ROW Alternative would cross the Cordelia Fault at the same location as the Proposed Route (See description for Segment 3, Section D.7.1). Approximately 800 feet east of Pennsylvania Ave, the mitigation segment would cross the UPRR tracks where it would rejoin the Existing Pipeline ROW Alternative route. The mitigation segment crosses the same paleontologically sensitive areas as those described for Segments 2 and 3 where these routes are coincident.

Mitigation Segment EP-2

As described in Section D.9 (Land Use), this 7.5-mile mitigation segment would diverge from the Existing Pipeline ROW Alternative route southwest of Davis by turning east onto Tremont Road, then north onto Mace Boulevard (Highway E6). It would rejoin the Existing Pipeline ROW Alternative and turn east into UPRR ROW where Mace Boulevard intersects the UPRR. There are no mapped surface faults along Mitigation Segment EP-2 for the Existing Pipeline ROW Alternative. The entire mitigation segment crosses modern marsh and alluvium (low paleontologic sensitivity).

D.7.1.4 Environmental Setting: No Project Alternative

The No Project Alternative would not alter existing potential for impacts due to continued use of the existing pipeline through loss of access to mineral or energy resources, unstable slopes, fault rupture, or liquefaction.

D.7.2 Applicable Regulations, Plans, and Standards

Geologic resources and geotechnical hazards are governed primarily by local jurisdictions. The conservation elements and seismic safety elements of city and county general plans contain policies for the protection of geologic features and avoidance of hazard, but do not specifically address pipeline construction. Local grading ordinances establish detailed procedures for pipeline construction, including trench backfill, compaction and testing.

D.7.2.1 Federal

Department of Transportation guidelines for the construction of liquid petroleum pipelines apply, as does the Pipeline Safety Improvement Act of 2002, the Act's amendments to Title 49 of the Code of Federal Regulations (CFR), and Parts 190, 192, 194, and 195 of 49 CFR. The applicable standards for pipeline design will include the Guidelines for the Design of Buried Steel Pipe from the American Lifeline Alliance (ALA, 2001) and the Guidelines for the Seismic Design of Oil and Gas Pipeline Systems from the American Society of Civil Engineers (ASCE, 1984).

D.7.2.2 State

In California, the Alquist-Priolo Earthquake Fault Zoning Act of 1972 (formerly the Special Studies Zoning Act) regulates development and construction of buildings intended for human occupancy to avoid the hazard of surface fault rupture. While this Act does not specifically regulate pipelines, it does help define areas where fault rupture is most likely to occur. This Act groups faults into categories of active, potentially active, and inactive. Historic and Holocene age faults are considered active, Late Quaternary and Quaternary age faults are considered potentially active, and pre-Quaternary age faults are considered inactive. These classifications are qualified by the conditions that a fault must be shown to be "sufficiently active" and "well defined" by detailed site-specific geologic explorations in order to determine whether building setbacks should be established.

The California Building Code (CBC, 2001) is based on the 1997 Uniform Building Code, with the addition of more extensive structural seismic provisions. Chapter 16 of the CBC contains definitions of seismic sources and the procedure used to calculate seismic forces on structures. As the Proposed Project lies within UBC seismic zones 3 and 4, provisions for design should follow the requirements of Chapter 16. Chapter 33 of the CBC contains requirements relevant to the construction of pipelines alongside existing structures. CCR Title 24, Section 3301.2 and 3301.3 *et seq.* contains the provision requiring protection of the adjacent property during excavations and requires 10 days written notice and access to the excavation be given to the adjacent property owners. Relevant owners would include the railroads along which the pipeline route or Existing Pipeline ROW Alternative are located.

D.7.2.3 Regional and Local

The safety elements of General Plans for the cities and counties along the proposed alignment contain policies for the avoidance of geologic hazards and/or the protection of unique geologic features. A survey of General Plans along the proposed alignment showed most municipalities require submittal of construction and operational safety plans for proposed construction in areas of identified geologic and seismic hazards for review and approval prior to issuance of permits. County and local grading ordinances establish detailed procedures for excavation and grading required during construction.

D.7.3 Environmental Impacts and Mitigation Measures for the Proposed Project

D.7.3.1 Introduction

General and construction related impacts both to and from the Proposed Project are described. General impacts are those that may need to be mitigated or inspected through the life of the project (e.g., those related to creeping fault crossings or unstable slopes). Construction impacts are those impacts having the potential to be encountered and/or mitigated during construction (e.g., liquefiable soils or significant fossils).

D.7.3.2 Definition and Use of Significance Criteria

Geologic conditions were evaluated with respect to the impacts the project may have on the local geology, as well as the impact specific geologic hazards may have upon the pipeline and the related facilities. The significance of these impacts was determined on the basis of CEQA statutes, guidelines and appendices, thresholds of significance developed by local agencies, government codes and ordinances, and requirements stipulated by California Alquist-Priolo statutes. Significance criteria and methods of analysis were also based on standards set or expected by applicable agencies for the evaluation of geologic hazards. Adverse impact on geologic, mineral, or paleontological resources would be considered significant and would require additional mitigation if:

- Construction activities or the siting of facilities would worsen existing unfavorable geologic conditions.
- Project construction or operation would preclude or disrupt the development of mineral resources.
- The location and design of the pipeline and related facilities in relationship to geologic hazards could result in a rupture or failure of the pipeline or cause damage to related facilities that would present a significant threat to public safety, as supported by historical performance of similarly designed pipelines that experienced geological hazards comparable to those present in the project area.

Adverse impact on soils would be considered significant and would require additional mitigation if project construction or operation would:

- Increase erosion or reduce soil productivity due to compaction or soil mixing to a level that would prevent successful rehabilitation and eventual reestablishment of vegetative cover to the recommended or pre-construction composition and density.
- Reduce agricultural productivity for longer than 3 years because of soil mixing, structural damage, or compaction.
- Increase exposure of human or ecological receptors to potentially hazardous levels of chemicals or explosives due to the disturbance of contaminated soils or to the discharge or disposal into soils of hazardous materials.
- Have the potential to be damaged by exposure to soils with moderate to high corrosion ratings, where the pipeline is not protected with appropriate coating and/or cathodic protection.
- Be located in areas with expansive soils that would damage aboveground structures.

The significance of paleontological remains can be determined by the types of fossils, the geologic age of the remains, the assemblage association (the unique biological association or organisms), the lithology and age of the rock units, and its rarity or uniqueness. A paleontological resource can be considered to have scientific or educational value if it:

- Provides important information on the evolutionary trends among organisms, relating living inhabitants of the earth to extinct organisms.
- Provides important information regarding development of biological communities or the interaction between botanical and zoological biota.
- Demonstrates unusual or spectacular circumstances in the history of life.
- Is in short supply and in danger of being depleted or destroyed by the elements, vandalism, or commercial exploitation, and is not found in other geographic locations.
- Is recognized as a natural aspect of our national heritage.
- Lived prior to the Holocene (~11,000 B.P.).
- Is not associated with an archaeological resource (as defined in Section 3(1) of the Archaeological Resources Protection Act of 1979 [16 USC 470bb(1)]).

A fossil specimen would be significant if it is (1) identifiable; (2) complete; (3) well preserved; (4) age diagnostic; (5) useful in environmental reconstruction; (6) a type or topotypic specimen; (7) rare taxon; (8) or part of a diverse assemblage. A paleontological impact would be considered significant and require additional mitigation if the resource is considered to have scientific or educational value and project construction or operation would result in damage or loss of vertebrate or invertebrate fossils that are considered important by paleontologists and land management agency staff.

D.7.3.3 Impacts of Pipeline Construction

Potential impacts were considered including loss of paleontological resources, landslides and slope creep, and seismic hazards (active fault rupture, seismic ground shaking, liquefaction, and seiches). Each of these potential impacts is discussed in conjunction with the Proposed Project in the following sections.

Impact G-1: Loss of Unique Geologic Features or Loss of Access to Mineral or Energy Resources

Construction of the linear pipeline could impact unique geologic features or access to mineral resources and/or energy resources. (Less than Significant, Class III)

Impact Discussion

The alignment traverses alluvium and artificial fill throughout most of its length, therefore the Proposed Project is not expected to significantly impact unique geologic features, such as outcrops or landmarks. Mineral resources along the proposed pipeline alignment are limited to sand and gravel that could be used for construction. Energy resources include productive gas fields in the Sacramento River Delta with associated storage tanks and pipelines. Construction and operation of the linear pipeline is not expected to significantly impact access to mineral or energy resources. Overall, impacts to unique geologic features and mineral or energy resources are expected to be less than significant (Class III).

Mitigation Measure. None required.

Residual Impact. This impact would be less than significant.

Impact G-2: Loss of Paleontological Resources

Pipeline construction could expose and damage paleontological resources. (Potentially Significant, Class II)

Impact Discussion

As discussed for the individual segments, numerous locations occur where the proposed pipeline crosses geologic units that are considered moderate to highly sensitive with respect to paleontological resources. Pipeline construction could expose and damage these resources, resulting in a potentially significant (Class II) impact. Where a Paleontologic Monitor is required, the CSLC will provide this monitoring. Mitigation Measure G-2a would reduce impacts to paleontological resources to less than significant levels.

Mitigation Measure for Impact G-2: Loss of Paleontological Resources

G-2a **Paleontological Resource Procedures. Paleontological resources may exist at the locations where the proposed alignment crosses moderate to highly sensitive units as follows:**

Paleontological monitoring of excavation within Mileposts 1.0 to 5.0, 11.0 to 15.5, 17.6 to 18.3, 26.1 to 30.8, 35.3 to 36.0, and 37.5 to 40.1 shall be completed by a qualified paleontologist. The paleontologist shall provide education and training of construction workers about potential paleontological resources that may be discovered and, subject to prior approval by the CSLC on a case-by-case basis, he/she will have the ability to stop construction if potentially significant resources are identified and threatened by the project. All specimens collected from public land shall be deposited at a curating institute such as the University of California at Berkeley Museum of Paleontology.

Residual Impact. With the implementation of G-2a, impacts to paleontological resources would be less than significant.

Impact G-3: Steep Slopes and Landslide Hazards

Slope failures or downslope creep of unstable natural or man-made slopes along the pipeline could lead to substantial pipeline damage or failure. (Potentially Significant, Class II)

Impact Discussion

Deeply weathered Sonoma Volcanics are susceptible to slope failures; this unit is present in the slopes west of I-680 between MP 15.1 and 15.25 (Segment 2). Although the pipeline would be buried at the base of these slopes, a deep-seated slope failure may involve bedrock and soil as deep or deeper than the pipeline. A slope failure would bend and stretch the pipeline, causing rupture. This is a potentially significant (Class II) impact, mitigable to less than significant levels with implementation of Mitigation Measure G-3.

Mitigation Measures for Impact G-3: Steep Slopes and Landslide Hazards

G-3 **Geotechnical Investigations at Landslide Crossings. Data generated from geotechnical investigations performed at all landslide crossings (MP 14.6 to 14.5, 15.1 to 15.3, and 19.81 to 19.83) shall be used to develop criteria to ensure that appropriate slope stabilization measures are included in the project design. These measures may include soil improvements, buttressing of the slopes, compaction of trench backfill, or deepening trenches to place the pipeline**

beneath potential slide activity. The results and recommendations of the geotechnical investigations shall be presented in a report to be delivered to the contractor prior to the final design of the pipeline. The recommendations of the geotechnical report shall be addressed and incorporated into the pipeline final design, and submitted to the CSLC for review and approval at lease 60-days in advance of construction.

Motor operated valves (MOVs) shall be placed at either side of any recognized landslide hazard zone if identified by a geotechnical investigation or by the CSLC as being necessary to prevent excess spillage in the event of a landslide-caused rupture. The location of the MOV at MP 15.27 may be combined with the recommended relocation of Manual Valve #4 (see Mitigation Measure G-7a). Locations of all MOVs shall be presented in the final pipeline design, coordinated with the location of such valves at active fault crossings, and subject to approval of the CSLC.

Residual Impact. With the implementation of Mitigation Measure G-3 impacts at landslide crossings would be less than significant.

Impact G-4: Railroad Under-Crossings

Due to surcharge loading attributable to trains, there could be a failure of an excavation in areas where the proposed pipeline crosses beneath active railroad ROW, which could seriously impact operation of the railroad. (Potentially Significant, Class II)

Impact Discussion

Where the proposed pipeline crosses beneath active railroad right of way (Segment 3, MP 21.7 and 22.0; Segment 5, MP 32.6; and Segment 6, MP 68.5, 68.6, and 68.9), trench and pipeline design should take into account the additional surcharge of passing trains. These excavations can be completed if sufficient safety precautions are implemented. However, failure of an excavation in these areas, due to surcharge loading attributable to trains, could seriously impact operation of the railroad. This represents a potentially significant, but mitigable (Class II) impact.

Mitigation Measure for Impact G-4: Railroad Under-Crossings

G-4a Construction Below Active Railroads. In areas where the pipeline excavation crosses beneath an active railroad, a geotechnical investigation shall be performed to develop criteria for stabilizing the excavation. These criteria shall account for periodic surcharge loading due to railroad operations; completion of the investigation shall be documented and submitted to the CSLC for review and approval at lease 60-days in advance of construction. The railroad shall be notified of the proposed excavation; a copy of the notification shall be provided to the CSLC.

Residual Impact. Implementation of Mitigation Measure G-4a would reduce this impact to less than significant.

D.7.3.4 Impacts of Pipeline Accidents

While a geologic condition (e.g., an earthquake or landslide) could cause a pipeline accident, no impacts to the geology, soils, or paleontology would occur as a result of a pipeline accident. Measures to improve pipeline safety in areas of geologic hazards are presented in Sections D.7.3.3, D.7.3.5, and

D.7.3.6. However, if repair and cleanup of an accident requires excavation and new pipeline construction, all relevant mitigation measures presented in the above sections should be implemented.

D.7.3.5 Impacts of Pipeline Operation

Seismic Hazards

Large abrupt differential displacements comprise the most severe hazard for a buried pipeline. Either landslides or earthquakes can generate this type of displacement. Rupture or severe distortion of the proposed pipeline may occur at the active and potentially active fault crossings along the project alignment. Seismically induced reactivation of landslides mapped near the project alignment along the Green Valley Fault is a significant potential hazard for a buried pipeline.

Impact G-5: Fault Rupture

Active fault crossings could result in pipeline rupture. (Significant, Class I)

Impact Discussion

Oil and gas pipelines can be designed to withstand substantial fault movement without rupture when the direction and magnitude of anticipated offset is well defined. However, because of the uncertainties regarding direction and magnitude of anticipated offset and because fault-crossing design has not been thoroughly tested by nature, two of the pipeline's active fault crossings (Concord and Green Valley faults) are designated as significant and unmitigable (Class I) impacts. Anticipated fault offset at the active Concord and Green Valley fault crossings ranges from three to six feet, but could be as great as 9.5 feet (URS, April 2003). Fault movement of this magnitude would likely result in pipeline rupture even if all protective design measures are implemented. Refer to the Department of Transportation publication “Common Ground” for pipeline best practices, to O’Rourke and Liu (1999), and to additional literature regarding pipeline design in areas of geologic hazards.

The pipeline crossing of the Cordelia Fault is designated a potentially significant but mitigable impact (Class II) because anticipated fault offset at this active fault ranges from one to two feet. The Vaca Fault crossing is also designated as a significant but mitigable (Class II) impact because of the lower probability of rupture during the design life of the project facilities. The Great Valley Fault is a blind thrust and is not expected to produce surface rupture, though it may produce extreme ground shaking over a broad area. Impacts from this type of movement can be mitigated with appropriate pipeline design measures.

Fault crossing design generally comprises a dual seismic design philosophy: construction of the pipeline to be as flexible as possible, and an emergency shutdown system in case of pipeline rupture. Pipeline flexibility would incorporate the use of thick walled, ductile steel pipe capable of moving laterally, vertically, and longitudinally to accommodate fault displacement by deforming without failing during fault rupture. Additionally, the risk of pipeline rupture is further reduced when this flexible pipeline is placed either (1) on cradles aboveground with as long an unsupported span as possible over fault crossings, or (2) within an over-excavated trench backfilled with granular material that would allow the pipe to deform within the trench but not break (O’Rourke and Liu, 1999).

At the Concord Fault crossing (MP 0.2 to MP 0.4), the project design currently calls for directional drilling to cross Walnut and Grayson Creeks to avoid impacts to the wetlands area. This construction method would preclude designing the pipeline to accommodate lateral or vertical movement caused by earthquake fault rupture. In addition to Mitigation Measure G-5a (requiring design of fault crossing parameters), Mitigation Measure G-5b is also recommended to provide immediate feedback on potential pipeline damage after a major earthquake in the project area.

With implementation of Mitigation Measures G-5a and G-5b, the risk of pipeline rupture at the three active fault crossings would be reduced. However, the Concord and Green Valley Faults have the potential for lateral movement of up to six feet, and no pipeline design measures would prevent rupture in that situation. Therefore, the risk of fault rupture is still considered to be significant (Class I).

Mitigation Measures for Impact G-5: Fault Rupture

G-5a General Fault Crossing Design Parameters. In order to develop site specific measures for final pipeline design for individual fault crossings, the Applicant shall complete final geotechnical studies at the Concord, Green Valley, and Cordelia Fault crossings to accurately define the fault plane location, orientation and direction of anticipated offset and to refine fault crossing design parameters prior to construction of the pipeline. In order to retain the pipeline's ductility, the pipeline shall be aligned to cross the fault with as close to a 90º angle as possible to avoid shortening or large compressive strains during fault movement. Other appropriate design and operational procedures to be considered for incorporation during final pipeline design include, but are not limited to, engineered backfill, thicker wall pipe, MOVs on either side of the fault crossings and/or use of seismic switches/alarms. The geotechnical reports shall be submitted to the CSLC and the affected counties' public works departments, and the recommendations shall be incorporated into the final pipeline design.

The required Supplemental Spill Response Plan defined in Mitigation Measure S-2a (Section D.2) will include adequate specific measures for containment, clean-up/restoration of product spills resulting from pipeline rupture that could possibly reach surface water and/or identified sensitive habitat either directly or through any conduit including overland or subsurface flow. However, the site-specific content of the Supplemental Spill Response Plan due to pipeline rupture at the following fault locations cannot be known until final pipeline design and shut-off valves are determined. At a minimum, the Supplemental Spill Response Plan shall be revised as necessary to reflect final pipeline design in the vicinity of the listed faults; submitted to the CSLC for review and approval at least 60-days prior to placing the pipeline in service; and contain the following information:

- **Delineation of the extent of the maximum expected worst-case product spill at each fault location;**
- **Characterization of the conditions and habitat value of the plants, animals, soil and water within the delineated area;**
- **Placement of sufficient, centrally located, spill response resources to minimize ecological damage resulting from a potential spill at the listed fault locations;**
- **A programmatic outline for the restoration of conditions and habitat values within the impacted area as characterized prior to the spill event;**
- **A commitment to the satisfaction of the CSLC for the payment of a mitigation fee, in-kind restoration of like-habitat, or other similar measures equivalent to the temporary loss in habitat value occurring from the time of spill to successful restoration as determined by approved methodologies of the Department of Fish and Game, U.S. Fish & Wildlife Service, or other appropriate agency.**

Concord Fault. Pipeline construction for the Concord Fault crossing shall be accomplished by HDD utilizing a minimum 0.5 inch pipe wall thickness and include a system for monitoring and controlled shutdown of the pipeline. This shall be accomplished through installation of an additional MOV at approximately MP 0.5 (or such other location determined by the CSLC during review and approval of final pipeline design plans) to limit the volume of product released should movement of the Concord Fault cause rupture of the pipeline. Pipeline design shall also follow the general parameters described above as appropriate.

Green Valley Fault. Pipeline construction for the Green Valley Fault crossings shall utilize a minimum 0.5 inch pipe wall thickness. MOVs shall be installed on both sides of the fault crossing to limit the volume of product released should rupture occur; these valves shall be installed at or near MP 10.0 and 10.52 or such other location determined by the CSLC during review and approval of final pipeline design plans. Pipeline design shall also follow the general parameters described above as appropriate.

Cordelia Fault. MOVs shall be installed on both sides of the fault crossing to limit the volume of product released should rupture occur; if determined to be necessary by the CSLC during review and approval of final pipeline design plans. Pipeline design shall also follow the general parameters described above as appropriate.

G-5b Pipeline Operations Plan. At least 60-days prior to placing the proposed pipeline into service, SFPP shall submit to the CSLC for final review and approval, a revised Pipeline Operations and Maintenance Plan (POMP). The POMP shall address internal and external maintenance inspections of the completed facility, including details of the integrity testing methods to be applied, corrosion monitoring and testing of the cathodic protection system, leak monitoring, emergency response procedures and protocols. The POMP shall also include and address all applicable operational mitigation measures contained in this document including, but not limited to, geohazard analysis for monitoring fault crossings, procedure for pigging the pipeline in the vicinity of fault crossings following a seismic event, liquefaction areas, landslide zones, and settlement. Within three months following promulgation of any new Federal or State regulation relating to issues and requirements contained in the approved POMP, SFPP shall update the POMP and submit a revised copy to the CSLC for review and approval.

SFPP shall incorporate the following practice into the POMP for review and approval by the CSLC at least 60-days in advance of construction:

- **Immediately following an earthquake within the parameters shown in the table below, that causes pipeline rupture, or that causes the pipeline to be shut-down, qualified SFPP operations personnel shall inspect all parts of the pipeline alignment that fall within the specified distance of the earthquake epicenter for evidence of ground deformation (e.g., cracks or displacements). If surface fault rupture is reported or observed, the pipeline alignment within at least 1,000 feet of the rupture shall be inspected. SFPP shall submit reports of its findings to the CSLC. In the event of pipeline shut-down or rupture due to a seismic event, the pipeline shall not be re-operated without prior review and approval by the CSLC.**

Earthquake Magnitude (Richter scale)	Epicentral Distance (miles)
6	5
6.5	10
7	15
7.5	20

Residual Impact. Even with the implementation of the above mitigation measure, impacts associated with the fault crossings (Concord and Green Valley faults) would still be significant and unmitigable. **A Statement of Overriding Considerations would be required for project approval.**

Impact G-6: Strong Ground Shaking

Strong earthquake-induced ground shaking could result in significant damage to aboveground structures and lead to failure of open trenches during construction. (Potentially Significant, Class II or Less than Significant, Class III)

Impact Discussion

Strong earthquake-induced ground shaking generally only impacts buried structures when the shaking induces ground failure such as settlement or liquefaction, or when the buried structure spans an abrupt change from stiff to soft or very soft soils. The impacts of settlement and liquefaction on the Proposed Project are discussed below (Impact G-7). Damage attributable to a transition from stiff to soft soils occurs when the soft soil allows large displacements of the buried structure, while the stiff soil restrains the structure.

The proposed alignment crosses a transition from stiff alluvium to soft estuarine deposits and back to stiff alluvium at the Walnut Creek and Grayson Creek crossings, near the Carquinez Strait crossing, and at approximately MP 18.9 and MP 19.7 near the Cordelia Creek crossing. However, since the Younger Bay Mud soils thin significantly as they approach the alluvium, displacement in the soft bay mud immediately adjacent to the stiff soils will likely be limited. Therefore, the impact is less than significant (Class III).

The Concord Station will experience strong ground shaking in an earthquake due to its location in Seismic Zone 4. Proper seismic design (Concord General Plan, 1996; CBC Chapter 16, 2001) will allow structures to withstand intense ground shaking without collapsing. However, there is a risk that the trench could collapse during construction (Class II), a potentially significant impact mitigable with the implementation of Mitigation Measure G-6a.

Mitigation Measure for Impact G-6: Strong Ground Shaking

G-6a Excavation Safety and Trench Design. In order to ensure the safety of excavations, a geotechnical investigation of the potential ground motions shall occur. The results and recommendations of the investigation shall be provided to the excavation design team and incorporated into the final trench design, subject to CSLC review and approval at least 60-days in advance of construction.

Residual Impact. Mitigation Measure G-6a would reduce impacts from strong ground shaking to less than significant.

Impact G-7: Liquefaction Potential

Liquefaction often results in loss of ground bearing capacity and/or lateral spreading, both of which could result in damage to engineered structures (i.e. pipelines). (Potentially Significant, Class II)

Impact Discussion

During loss of ground bearing capacity, large deformations can occur within the soil mass, allowing buildings to settle and tilt. If structures are buoyant, they may float upward. The most serious liquefaction hazard results from burial of the pipeline in a competent soil that overlies deeper liquefiable soil layers. Liquefaction of the deeper layers may result in substantial lateral spreading of the upper competent soil. Lateral spreading can extend several hundred feet back from a slope and displacements of tens of feet may occur if soil conditions are especially favorable for liquefaction and if earthquake shaking is of sufficient duration. A good example of lateral spreading occurred during the 1971 San Fernando Earthquake, when an area of almost 163 acres moved down a 2.5 percent slope. In addition, lateral spreading was responsible for most of the pipeline failures in San Francisco during the 1989 Loma Prieta Earthquake.

Lateral spreading along the Proposed Project alignment is particularly likely in the vicinity of unlined stream and river channels or other sloping locations such as those along Walnut and Grayson Creeks in Concord, and along the Deep Water Ship Channel and Turning Basin in West Sacramento. Damage induced by lateral spreading and liquefaction is generally most severe when liquefaction occurs within 15 to 20 feet of the ground surface.

The potential for liquefaction and lateral spreading damage to the pipeline is designated as a potentially significant (Class II) impact, mitigable to less than significant levels by implementation of Mitigation Measure G-7a.

Mitigation Measure for Impact G-7: Liquefaction Potential

G-7a Reduce Liquefaction Hazard. Final geotechnical investigations shall be conducted in the areas underlain by Younger Bay Mud and by recent alluvium at all creek and river crossings, including soils in the Yolo Bypass and near the Deep Water Ship Channel. EIR Table D.7-4 lists the mileposts at each location of potential liquefaction (boundaries between significantly different soil types). The results and recommendations of the geotechnical investigations shall be incorporated into the final pipeline design. If moderate to high liquefaction potential is confirmed by geotechnical analyses, then design measures shall be implemented at the corresponding location. Appropriate design is dependent on site-specific conditions and could include the following specific options:

- **Burial of the pipeline in competent soil below the liquefiable soil layer prevents any liquefaction hazard to the pipeline. However, liquefiable soils often extend down to a depth of 20 to 50 feet. Therefore, it may be impractical to consider this mitigation in all circumstances.**
- **Burial of the pipeline within the liquefiable layer often results in uplift forces on the pipeline. The impact of uplift on the pipeline can be mitigated through the use of densification techniques, such as stone columns, vertical anchors (tension piles), concrete coating on the pipe, or by use of thicker-walled, ductile steel pipe.**
- **The impacts of lateral spreading in areas where the pipeline is buried in a competent layer above the zone of liquefiable soil can be mitigated through the use of the same design considerations that apply at fault crossings (see Mitigation Measure G-5a). The route should be selected to avoid large compressive strains; thick-walled, ductile steel pipe should be used; and the pipe should be buried in a shallow trench to limit the lateral and friction forces on the pipe.**

The final geotechnical studies and design recommendations that result from this mitigation measure shall be provided to the CSLC for review and approval at least 60 days before construction.

Residual Impact. Mitigation Measure G-7a would reduce the liquefaction hazards to less than significant.

Impact G-8: Seiches

A seiche could remove the cover and damage the pipeline. (Potentially Significant, Class II)

Impact Discussion

The potential for seiche inundation is limited to the Carquinez Strait crossing in Segment 1. Given the relatively high probability of a major earthquake in this region, and the relatively flat topography at these locations, a seiche could be expected to generate sufficient erosive energy to remove the cover and damage the pipeline. Therefore, the potential for seiche inundation is designated as a potentially significant (Class II) impact, mitigable with implementation of Mitigation Measure G-8a.

Mitigation Measure for Impact G-8: Seiches

G-8a Protection from Seiche Inundation. Final geological investigations shall be conducted in the vicinity of the Carquinez Strait crossing points to identify and map local conditions that may be impacted by a series of seiche waves on the order of 3 to 5 feet high. The report shall provide specific recommendations about where to place erosion protection for the buried pipeline. Possible forms of protection from the erosive action of seiche waves could include armoring of slopes facing the water by either paving or placement of rip-rap, or where the topography is very flat, placement of an armored berm over or across the pipeline.

SFPP shall re-survey and submit a report to the CSLC describing the condition and depth of cover over the existing 14-inch pipeline at the crossing of Carquinez Strait. A minimum of 5-feet of cover shall be maintained to the satisfaction of the CSLC, unless an equivalent method of protection is approved.

Residual Impact. Mitigation Measure G-8a would reduce impacts from seiche inundation to less than significant.

Impact G-9: Soils

Problematic soils could impact pipeline operation, and pipeline construction and operation could impact soils. (Less Than Significant, Class III)

Impact Discussion

Corrosive soils occur along the proposed alignment wherever soils with low pH or high sulfate concentration are present (e.g., soils developed over Bay Mud). Expansive soils occur where soils are developed over material weathered from volcanic rocks (e.g., some of the Sonoma Volcanics may generate expansive soils). The applicant's use of coated pipe and cathodic protection will likely prevent development of a significant (Class III) impact. Preparation and placement of trench bedding and backfill in accordance with current design practices will reduce the impact from expansive soil to less than significant. Erodible soils occur where the soil components are very fine-grained and unconsolidated; no such soils are mapped along the proposed alignment. Pipeline impacts on soils include loss of agricultural soil when pipelines traverse cultivated fields; this issue is addressed in Section D.9 (Land Use).

Mitigation Measure. None required.

Residual Impact. This impact would be less than significant.

D.7.3.6 Geologic Impacts by Segment

Each of the potential impacts designed above is addressed in this section by pipeline segment, including excavation failure, seismic hazards, slope stability, problematic soils, and mineral and paleontological resources. This section combines discussion of construction and operational impacts.

Segment 1 (MP 0–6.1) – Contra Costa County and Carquinez Strait

The alignment as proposed crosses an active surface trace of the Concord Fault at approximately MP 0.3 beneath Walnut Creek and within the HDD stream crossing of Walnut and Grayson Creeks (Impacts G-5 and G-7). The alignment lies within the Alquist-Priolo Earthquake Hazard Zone for the Concord Fault between about MP 0.1 and 0.5 and from MP 0.6 to 0.7 where extremely high levels of ground shaking would be experienced if a Concord Fault earthquake occurred during construction (Impact G-6). Worker safety could be impacted due to collapse of excavations or failure of facilities during strong earthquake shaking or fault rupture (Impacts G-5, G-6, and G-7). Mitigation Measures G-5a, G-6a, G-6a, and G-7a should be implemented to reduce impacts from seismic hazards to less than significant (Class II).

Phase 1 Carquinez Strait crossing

This area poses potential risk to worker safety and potential pipeline exposure due to inundation by seiche waves (Impact G-8). After implementation of Mitigation Measure G-8a, the residual impact would be less than significant.

Phase 2 Carquinez Strait crossing

This crossing would create the same potential risk to worker safety due to inundation by seiche waves as Phase 1 (Impact G-8). The potential risk from seiche wave inundation to both workers and the pipeline is the same for equivalent elevations as those for Phase 1.

Segment 2 (MP 6.1–17.6) – Benicia and I-680 Frontage

Paleontologic resources may be impacted during construction in this segment (Impact G-2). After implementation of Mitigation Measure G-2a, the residual impact would be less than significant.

This segment crosses the Green Valley Fault as well as several areas of unstable slopes (Impacts G-3, G-5, G-6, and G-7). Potential impacts are to worker safety due to collapse or failure of the pipeline during strong earthquake shaking, liquefaction, or fault rupture (Impacts G-5, G-6, and G-7). After implementation of Mitigation Measures G-5a, G-5b, G-6a, and G-7a, the residual impact would be less than significant. Unstable slopes can be mobilized due to construction activities or as a result of earthquake ground shaking, putting workers and the pipeline at risk in these areas (Impact G-3).

Slope failures or downslope creep of unstable natural or man-made slopes along the pipeline could lead to substantial pipeline damage or failure (Class II). Therefore, a manual valve is proposed at MP 15.17; this location lies within the mapped extent of a landslide, a potentially significant (Class II) impact. After implementation of Mitigation Measure G-3a, the residual impact from steep slopes and landslides along the proposed route would be less than significant.

Mitigation Measure for Impact G-3: Steep Slopes and Landslide Hazards

G-3b Valve Relocation. The valve proposed at MP 15.17 shall be relocated outside of the mapped extent of the landslide (e.g., to MP 15.27), unless the results of geotechnical studies approved by the CSLC determine otherwise.

Residual Impact. With the implementation of Mitigation Measure G-3a, this impact would be less than significant.

Segment 3 (MP 17.6–24.5) – Cordelia

Paleontologic resources may be impacted during construction on this segment (Impact G-2). After implementation of Mitigation Measure G-2a, the residual impact would be less than significant.

This segment crosses the southern end of the Alquist-Priolo zoned Cordelia Fault and will be subject to fault rupture, ground shaking, and potential liquefaction (Impacts G-5, G-6, and G-7, respectively). After implementation of Mitigation Measures G-5a, G-5b, G-6a, and G-7a, the residual impact would be less than significant.

To avoid a sensitive plant species, from MP 19.8 to MP 19.9 the proposed alignment crosses a mapped landslide. Special care should be taken to design the pipeline so that renewed movement of the landslide will not rupture it (Impact G-3). After implementation of Mitigation Measure G-3a, the residual impact would be less than significant.

Cordelia Mitigation Segment

As discussed in Section D.4 (Biological Resources), this mitigation segment was developed to avoid sensitive biological and water resources within Cordelia Marsh and Slough. The 2.6-mile segment diverges from the proposed route at MP 17.6 and rejoins the proposed route at approximately MP 20.0. The Cordelia Mitigation Segment parallels Ramsey Road until Cordelia Road, where it continues along Cordelia Road to the UPRR ROW where it rejoins the proposed route (see Figure D.4-3).

Similar to the Proposed Project, the Cordelia Mitigation Segment would cross the Alquist-Priolo zoned Cordelia Fault and will be subject to fault rupture, ground shaking, and potential liquefaction (Impacts G-5, G-6, and G-7, respectively). However, with implementation of Mitigation Measures G-5a, G-5b, G-6a, and G-7a, impacts would be less than significant (Class II). The mitigation segment would avoid a landslide area mapped from MP 19.8 to 19.9 of the proposed route, resulting in no impacts. The Cordelia Mitigation Segment is slightly preferred to the Proposed Project segment.

Segment 4 (MP 24.5–30.7) – Fairfield/Suisun City

Paleontologic resources may be impacted during construction in this segment (Impact G-2). After implementation of Mitigation Measure G-2a, the residual impact would be less than significant.

While this segment does not cross an active fault, it will likely be subject to ground shaking and potential liquefaction (Impacts G-6 and G-7). After implementation of Mitigation Measures G-5a, G-5b, G-6a, and G-7a, the residual impact would be less than significant.

This segment crosses a railroad right of way at MP 24.8 and 30.1. Worker and operational safety may be impacted due to failure of the excavation during surcharge loading by trains (Impact G-4). After implementation of Mitigation Measure G-4a, the residual impact would be less than significant.

Segment 5 (MP 30.7–65.1) – Solano and Yolo Counties Agricultural Area

Paleontologic resources may be impacted during construction (Impact G-2). After implementation of Mitigation Measure G-2a, the residual impact would be less than significant.

This segment crosses the Vaca Fault and may be subject to fault rupture, ground shaking, and potential liquefaction (Impacts G-5, G-6, and G-7, respectively). After implementation of Mitigation Measures G-5a, G-5b, G-6a, and G-7a, the residual impact would be less than significant (Class II).

This segment crosses a railroad right of way at MP 32.6. Worker and operational safety may be impacted due to failure of the excavation during surcharge loading by trains (Impact G-4). After implementation of Mitigation Measure G-4a, the residual impact would be less than significant.

Segment 6 (MP 65.1–69.9) – West Sacramento

This segment will likely be subject to ground shaking, potential liquefaction, and possible lateral spreading (Impacts G-5, G-6, and G-7, respectively). After implementation of Mitigation Measures G-5a, G-5b, G-6a, and G-7a, the residual impact would be less than significant.

This segment crosses a railroad right of way at MP 68.5, 68.6, and 68.9. Worker and operational safety may be impacted due to failure of the excavation during surcharge loading by trains (Impact G-4). After implementation of Mitigation Measure G-4a, the residual impact would be less than significant.

Segment 7 – Wickland Connection

Geologic impacts for Segment 7 are the same as those for Segment 6, except that there is no railroad crossing along this segment so Impact G-4 does not apply.

D.7.3.7 Impacts of Proposed Station Changes and Valves

The proposed modifications at the both the Concord and Sacramento Station and valve construction would have no impact on the geology, soils or paleontology, nor are there any impacts on the stations from geology, soils or paleontology beyond those described for the pipeline itself.

D.7.3.8 Cumulative Impacts

Potential cumulative geologic impacts are limited to the loss of paleontologic resources by the Proposed Project and one or more future projects. Seismic impacts comprise the impact of the geologic environment on the project and are not cumulative; however, existing levels of seismic risk would remain, because the project alignment crosses several active faults. The planned (approved) construction of the Zone 1 Reservoir (5 MG capacity) on the slopes above the proposed pipeline alignment at approximately MP 15.6 within 0.5 mile of the active Green Valley Fault would constitute a potentially significant cumulative impact in the event of a seismically induced reservoir failure that resulted in flooding and erosion of the pipeline, although specific details of reservoir design and location have not been evaluated.

D.7.4 Environmental Impacts and Mitigation Measures for Existing Pipeline ROW Alternative

Many of the same potential impacts that were considered for the Proposed Project would also occur for the Existing Pipeline ROW Alternative, including excavation failure, seismic hazards, slope stability, and problematic soils. Because the pipeline will be excavated in previously disturbed soil and rock, there will be no impact to paleontological resources. Nearly the entire route of this alternative would be very near a railroad ROW, so Mitigation Measure G-4a would be required to ensure worker safety (Impact G-4).

In Contra Costa County, the Existing Pipeline ROW Alternative alignment crosses an active trace of the Concord Fault approximately 2.5 miles north of the proposed new crossing. The alignment also lies within the Alquist-Priolo Earthquake Hazard Zone for the Concord Fault for approximately the first three miles of the route. Extremely high levels of ground shaking would be experienced if a Concord Fault earthquake occurred. Worker safety could be impacted due to collapse of excavations or failure of facilities during strong earthquake shaking or fault rupture (Impacts G-5, G-6, and G-7). Mitigation Measures G-5a, G-5b, G-6a, and G-7a should be applied to minimize impacts from geologic hazards. These impacts would be less than significant if recommended mitigation is implemented.

For the crossing of the Carquinez Strait, impacts at this crossing from potential seiche wave inundation (Impact G-8) would be the same as those of the Proposed Project.

In the Benicia and Suisun Marsh area, the Existing Pipeline ROW Alternative would cross the Green Valley Fault but would avoid the mapped landslides on the west side of I-680. Potential impacts would result from pipeline rupture due to collapse or failure of facilities during strong earthquake shaking or fault rupture. Mitigation Measures G-5a and G-5b should be implemented to reduce the impact from fault rupture at the active Green Valley Fault (Impact G-5 and G-6). Potential liquefaction hazards exist along this segment as much of the existing pipeline crosses Suisun Marsh (Impact G-7).

The segment of this alternative through the cities of Fairfield and Suisun City is largely identical to Segment 4 of the proposed pipeline alignment. While this segment does not cross an active fault, it would likely be subject to ground shaking and potential liquefaction (Impacts G-6 and G-7). Mitigation Measures G-6a and G-7a should be implemented and would reduce seismic impacts to less than significant levels (Class II).

In the vicinity of the cities of Dixon and Davis, this alternative route would also cross the Vaca Fault near Vacaville Junction and could be subject to fault rupture, ground shaking, and potential liquefaction (Impacts G-5, G-6, and G-7, respectively). However, this impact would be less than significant (Class II) with mitigation. This segment has several short water crossings that may respond to strong seismic shaking with liquefaction and lateral spreading. Mitigation Measures G-5a, G-5b, G-6a, and G-7a are required.

Finally, in the City of West Sacramento, the existing pipeline ROW would likely be subject to ground shaking (Impact G-6), potential liquefaction, and possible lateral spreading (Impact G-7), especially near the major waterways. Similar to Segment 6 of the proposed route, Mitigation Measures G-6a and G-7a would reduce these impacts to less than significant.

Mitigation Segment EP-1

The Mitigation Segment EP-1 for the Existing Pipeline ROW Alternative would cross two mapped traces of the Green Valley Fault at approximately MP 10.3 and MP 10.5 and crosses the Cordelia Fault at approximately MP 18.2 at acute angles. Mitigation Measures G-5a and G-5b would apply to these fault crossings as described for Segments 2 and 3 above.

Mitigation Segment EP-2

The Mitigation Segment EP-2 for the Existing Pipeline ROW Alternative would not encounter any significantly different geologic, soils, or paleontologic conditions than the Existing Pipeline ROW Alternative segment it replaces.

D.7.5 Environmental Impacts of the No Project Alternative

The No Project Alternative could require some construction along existing pipeline routes (pipe requirement and booster pump stations), with potential for creating worker safety impacts or affecting paleontological resources. Existing levels of seismic risk would remain, because the 36-year-old existing pipeline crosses several active faults. In the absence of the authority to implement mitigation measures, the impacts of the active fault crossings (Impact G-5) would be significant (Class I). Operation of trucks and trains would have no effect on geologic features or impacts.

D.7.6 Mitigation Monitoring, Compliance, and Reporting Table

Table F-6 (see Section F) presents the mitigation monitoring program for geology, soils, and paleontology.